Infectious Disease Principles

Disease Definitions

- **Host** - organism which provides nutrients, etc. to another organism
- **Parasite** - organism which lives at the expense of (and may even harm) its host; the parasite is generally smaller than the host and is metabolically dependent upon it
- **Disease** - an upset in the homeostasis of the host, resulting in generation of observable changes
    - **sign** - *objective* evidence of damage to the host (fever, rash, vomiting)
    - **symptom** - *subjective* evidence of damage to the host (headache, anorexia)
- **Infectious disease** - one in which detrimental changes in health of the host occur as a result of damage caused by a parasite
- **Pathogen** - microorganism that is capable of causing disease
- **Virulence** - a measure of **pathogenicity**, which is the ability to cause disease
    - **Virulent** - microorganisms that readily cause disease (only small numbers of the microorganism are required to initiate and sustain infection)
    - **Attenuated** - microorganisms with reduced ability to cause disease
    - **Avirulent** - microorganisms that do *not* cause disease
    - **Opportunistic** - microorganisms that *may or may not* cause disease generally *colonize*, but do not infect, the host when *usually* found associated with a host, called *normal microbiota* can cause disease if they are inadvertently introduced into a site where they do not usually reside, especially inside host tissues

Steps in Pathogenesis

To cause disease, a pathogen *must*:

- **Contact** the host - be *transmissible*
- **Colonize** the host - adhere to and grow or multiply **on** host surfaces
- **Infect** the host - proliferate **in** host cells or tissues
- **Evade** the host defense system - by avoiding contact that will damage it
- **Damage** host tissues - by physical (mechanical) or chemical means

Virulence Factors

Factors responsible for the virulence of a microorganism because they influence its ability to cause disease by affecting its **invasiveness** and/or its **toxigenicity**

- **Adhesins** - enable parasites to attach to host cells or tissues
- **Invasins** - enable parasites to enter and/or move through host cells or tissues
- **Evasins** - enable parasites to escape from host defenses
- **Toxins** - enable parasites to damage host cells

Microorganisms

Comparison of Eukaryotes, Prokaryotes, and Viruses

- **prokaryotes** - small, "simple" cells that typically have a cell walland cytoplasmic membrane surrounding their cytoplasm, which contains ribosomes and one (or more) chromosomes (contain genes made up of DNA), but have nomembranes surrounding their nucleus or organelles
- **eukaryotes** - large, complex cells with a nucleus that contains multiple chromosomes (contains genes of DNA) surrounded by a membrane and cytoplasm containing ribosomes and membrane-bound organelles, such as mitochondria, vacuoles, chloroplasts (plants only), golgi bodies, etc.
- **viruses** - acellular, nonliving entities, made up of genetic information (DNA or RNA) enclosed in a protein coat (some also have a membranecalled an envelope), which can reproduce themselves only by infecting cells and utilizing cellular materials and processes ... more info on viruses

Bacteria s

- **morphology** - these **prokaryotes** are typically ~0.2-2 x 1-5 um and may be cylindrical (bacilli), spherical (cocci), helical (spirilla or spirochetes) or polymorphic (many shaped or amorphous)
    - **cell wall** - rigid structure (peptidoglycan +/- lipopolysaccharide) that protects against osmotic pressure damage and provides cell shape - cylindrical (bacillus); spherical (coccus); helical (spirillum)
    - **cytoplasmic membrane** - this lipid/protein outer boundary of the cytoplasm regulates what goes in and out of the cell (permeability)
    - **ribosomes** - small RNA/protein particles required for protein synthesis
    - **chromosome** - large single strand of DNA that contains the "blueprint" for all cell structure and activity in regions called **genes**
    - **plasmids** - DNA that contains only a few genes and is exchanged between bacteria (codes for antibiotic resistance or virulence factors)
    - **inclusions** - intracytoplasmic storage bodies (may contain phosphates, iron, lipids, etc.)
    - **capsule** - polysaccharide "coatings" secreted by cells (adhesins)
    - **flagella** - long, thin protein (flagellin) polymers that provide motility
    - **pili** - long, thin protein (pilin) polymers that act as adhesins
    - **endospore** - thick-walled protective structures; highly resistant to adverse environmental conditions (high temperature, drying, O2, etc.)
- **growth** - process of cell enlargement and proliferation (increase in number)
    - **proliferate by *binary fission*** - division of a cell into two cells of *equal* size and composition
    - **growth curve** - phases:
        - **lag** - cells get ready to synthesize components needed for growth
        - **log** - rapid proliferation (exponential or **log**arithmetic); generation time (gt) is the time required for the number of cells to double

        - **stationary** - cell proliferation is balanced by cell death caused by nutrient depletion or accumulation of metabolic by-products
        - **death** - rapid (logarithmic) cell death occurs
    - **nutritional requirements**
        - **chemical** - they derive their energy and nutrition from organic compounds that they digest extracellularly using enzymes they secrete
            - **water** - living biological entities are typically ~70% water
            - **essential elements** - C (carbon), H (hydrogen), O (oxygen), N (nitrogen), P (phosphorus), S (sulfur)
            - **trace elements** - Ca (calcium), Mg (magnesium), Fe (iron), Na (sodium), K (potassium), Zn (zinc), Co (cobalt), Mn (manganese), plus others
            - **organic growth factors** - vitamins and other essential organic nutrients
        - **physical**
            - **temperature** - pathogenic bacteria grow best between 20C and 40C (human body temperature is 37C)
            - **oxygen** - **aerobes, facultative aerobes, microaerophiles, anaerobes**
            - **pH** - most pathogenic bacteria "prefer" near-neutral conditions (**pH ~6-8**), but some can thrive in acid (pH down to 3) or alkali (pH up to 10)
            - **salts** - no special requirements; pathogenic bacteria grow well at salt concentrations found in the human body
- **importance and habitat** - most bacteria are **saprophytic** (decomposers), but some are **pathogenic**; as a group, they are found everywhere

Fungi

- **morphology** - these **eukaryotes** have small cells (1-5 um), but may form aggregates that are visible to the naked eye
    - **single-celled** (yeasts) or **multicellular** (filamentous mycelium made up of many hyphae ... more about hyphae)
    - **cytoplasmic membrane** - this lipid/protein outer boundary of the cytoplasm regulates what goes in and out of the cell (permeability)
    - **cell wall** - rigid structure (contains chitin) that protects against osmotic pressure damage and provides cell shape - cylindrical (bacillus); spherical (coccus); helical (spirillum)
    - **capsule** - polysaccharide "coatings" secreted by cells (adhesins)
    - **ribosomes** - small RNA/protein particles required for protein synthesis
    - **chromosomes** - multiple DNA-containing structures that contain the "blueprint" for all cell structure and activity in regions called **genes**
- **growth** - process of cell enlargement and proliferation (increase in number)
    - **reproduce or proliferate** by:
        - **binary fission** - division of a cell into two cells of *equal* size and composition

        - **budding** - division of a cell into two cells of *unequal* size, but equivalent composition
        - **spore** formation - spores are generated by adults and germinate to form new fungal cells
    - **nutritional requirements**
        - **chemical** - they derive their energy and nutrition from organic compounds that they digest extracellularly using enzymes they secrete
            - **water** - living biological entities are typically ~70% water
            - **essential elements** - C (carbon), H (hydrogen), O (oxygen), N (nitrogen), P (phosphorus), S (sulfur)
            - **trace elements** - Ca (calcium), Mg (magnesium), Fe (iron), Na (sodium), K (potassium), Zn (zinc), Co (cobalt), Mn (manganese), plus others
            - **organic growth factors** - vitamins and other essential organic nutrients
        - **physical**
            - **temperature** - pathogenic fungi grow best between 20C and 40C (human body temperature is 37C)
            - **oxygen** - **aerobes** and a few **facultative aerobes**
            - **pH** - most infectious fungi "prefer" slightly acidic conditions **pH ~5-6**
            - **salts** - no special requirements; pathogenic fungi grow well at salt concentrations found in the human body
- **importance and habitat** - mostly decomposers (**saprophytes**), but some are **pathogens;** prefer **dark, moist** habitats containing organic material

Protozoa

- **morphology** - these unicellular **eukaryotes** have larger cells (10-100 um) than fungi or bacteria
    - **cytoplasmic membrane** - this lipid/protein outer boundary of the cytoplasm regulates what goes in and out of the cell (permeability)
    - **cell wall** - ***none***, but many for a pellicle just "inside" the cytoplasmic membrane
    - **contractile vacuoles** - regulate osmotic pressure by water expulsion
    - **ribosomes** - small RNA/protein particles required for protein synthesis
    - **chromosomes** - multiple DNA-containing structures that contain the "blueprint" for all cell structure and activity in regions called **genes**
    - **pseudopodia** or **undilipodia** (cilia, flagella) provide **motility**
    - **cyst** - dormant form; protects against adverse conditions
- **growth** - process of cell enlargement and proliferation (increase in number)
    - **proliferate** by:
        - **binary fission** - division of a cell into two cells of *equal* size and composition
        - **budding** - division of a cell into two cells of *unequal* size, but equivalent composition

        - **zygote** formation - during mating, gametes fuse to form a zygote, which develops into a egg, then (when conditions are "right") matures to form offspring
    - **nutritional requirements**
        - **chemical** - they derive their energy and nutrition from organic compounds that they digest intracellularly (holozoic) or from organic compounds that they digest extracellularly using enzymes they secrete (saprozoic)
            - **water** - living biological entities are typically ~70% water
            - **essential elements** - C (carbon), H (hydrogen), O (oxygen), N (nitrogen), P (phosphorus), S (sulfur)
            - **trace elements** - Ca (calcium), Mg (magnesium), Fe (iron), Na (sodium), K (potassium), Zn (zinc), Co (cobalt), Mn (manganese), plus others
            - **organic growth factors** - vitamins and other essential organic nutrients
        - **physical**
            - **temperature** - pathogenic protozoa grow best between 20C and 40C (human body temperature is 37C)
            - **oxygen** - most are **aerobic**, but some are **anaerobic**
            - **pH** - most infectious protozoa "prefer" near-neutral conditions **pH ~6-8**
            - **salts** - no special requirements; pathogenic protozoa grow well at salt concentrations found in the human body
- **importance and habitat** - free-living protozoa (moist environments) are a basic part of food chains and webs; **parasites** are major causes of **infectious disease** in humans and other animals

Helminths

- **morphology**
    - **multicellular eukaryotes** which possess **organs and organ systems** made up of tissues that are made up of cells, which have these characteristics:
        - **cytoplasmic membrane** - this lipid/protein outer boundary of the cytoplasm regulates what goes in and out of the cell (permeability)
        - **cell wall** - *none*
        - **ribosomes** - small RNA/protein particles required for protein synthesis
        - **chromosomes** - multiple DNA-containing structures that contain the "blueprint" for all cell structure and activity in regions called **genes**
    - **flatworms** *vs.* **roundworms**:
        - **flatworms** have flattened bodies that are:
            - slender and broadly leaflike flukes (Trematodes), which are microscopic
            - long and ribbonlike tapeworms (Cestodes), some of which may be 10 meters long
        - **roundworms** (*Nematodes*) have round elongated bodies and range in size from microscopic to several centimeters in length

    - **holdfasts** (hooks, suckers, etc.) attach parasitic forms to host tissues (adhesins)
- **growth** - process of cell enlargement and proliferation (increase in number)
    - **proliferate** by:
        - **zygote** formation - mating leads to fertilized eggs (ova) which are released into the environment, to mature into offspring; *Cestodes* and *Trematodes* are generally hermaphroditic (one worm possesses both male and female reproductive organs)
        - many have complicated life-cycles requiring more than one host
    - **nutritional requirements**
        - **chemical** - they derive their energy and nutrition from organic compounds (roundworms *ingest* food, whereas flatworms *absorb* nutrients
            - **water** - living biological entities are typically ~70% water
            - **essential elements** - C (carbon), H (hydrogen), O (oxygen), N (nitrogen), P (phosphorus), S (sulfur)
            - **trace elements** - Ca (calcium), Mg (magnesium), Fe (iron), Na (sodium), K (potassium), Zn (zinc), Co (cobalt), Mn (manganese), plus others
            - **organic growth factors** - vitamins and other essential organic nutrients
        - **physical**
            - **temperature** - pathogenic helminths grow best between 20C and 40C (human body temperature is 37C)
            - **oxygen** - **aerobic** (no known anaerobes)
            - **pH** - most infectious helminths "prefer" near-neutral conditions **pH ~6-8**
            - **salts** - no special requirements; pathogenic helminths grow well at salt concentrations found in the human body
    - **importance and habitat** - **decomposers** are found **everywhere** (especially roundworms); **parasitic** forms cause **disease** in plants or animals

Viruses

- **morphology** - very small (10 nm to 0.2 um)
    - **nucleocapsid**
        - **nucleic acid** - viral genes are made up of **either** DNA **or** RNA
        - **capsid** - protein coat made up of subunits called **capsomeres**
    - **envelope** - (optional) membrane "stolen" from host cell
- **growth** - they do not grow; they proliferate, but **only inside host cells** (viruses are obligate intracellular parasites) by a process called **replication**, which includes these steps:
    - **attachment** - to receptor sites on host cell by spikes (**peplomers**)
    - **penetration** - entrance into host cell
    - **uncoating** - removal of capsid(s); frees the viral genes to be expressed
    - **synthesis** - formation of viral DNA or RNA and proteins
    - **assembly** - components assemble to form viral nucleocapsids
    - **release** - viral particles (virions) "emerge" from the host cell by lysis or "budding"

- **importance and habitat** - pathogenic; ubiquitous, function only **in** living cells

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Virulence Factors

Virulence factors mediate the pathogenic activities of all microbes, as seen by these examples:

- **Adhesins** - promote **attachment** to host cells and tissues, which allows bacteria to contact and colonize host surfaces
    - **pili** - *Escherichia coli* and *Neisseria gonorrhoeae* use these to attach to urethral cells; *Salmonella* and *Escherichia coli* use them to attach to intestinal cells; fungi that infect in their yeast form use capsules for attachment
    - **capsules** - *Escherichia coli* uses these for attachment to intestinal cells
    - **hemagglutinins** - bacteria (*Salmonella* and *Bordetella*) and many viruses use these to attach to various host cells
    - **type III secretion system** - *Escherichia coli* uses this to aid attachment to intestinal cells ... and introduce toxins, etc. into host cells (type III secretion system - Escherichia coli uses this to aid attachment to intestinal cells ... check out this E. coli animation to see how the type III secretion (injector) system is used to facilitate this process
    - **spikes (peplomers)** - used by viruses to attach to cells they then infect
    - **holdfasts**
        - **suckers** are used by some protozoa (*Giardia*) and some helminths (*Echinococcus, Schistosoma*)
        - **mouthparts with "teeth"** are used by helminths (especially tapeworms) to attach to host surfaces
    - **hyphal tips** - fungi have molecules at the tips of their hyphae that attach to host cells
    - **adhesive disc** - Giardia uses a ventral adhesive disc to attach to intestinal cells
    - **apical complex** - some protozoa (Apicocomplexa such as *Plasmodium*, *Toxoplasma*) use their apical complex to attach to host cells
    - *Entamoeba histolytica* binds to intestinal cells using lectins to attach to polysaccharides on intestinal cells
- **Invasins** - promote **entrance** into and/or movement through tissues or cells, which allows bacteria to **infect** the host
    - **digestive enzymes** - break down barriers to infection
    - **fibrinolysin** - enzyme produced by *Staphylococcus aureus* and *Streptococcus pyogenes* that dissolves blood clots, thus preventing bacterial isolation and promoting spreading
    - **hyaluronidase** - enzyme produced by bacteria like *Staphylococcus aureus* and *Streptococcus pyogenes* that digests connective tissue, allowing them to spread through tissues more readily

    - **hemolysins** - enzymes produced by bacteria like *Clostridium perfringens* and *Staphylococcus aureus* that dissolve red blood cells, causing anemia and limiting oxygen delivery to infected tissues
    - **type III secretion system -** *Salmonella* uses this to invade intestinal cells ... by inducing phagocytosis by host cells ... check out this Salmonella animation to see how the type III secretion (injector) system is used to induce phagocytosis by host cells
    - **hyphal extension** - fungi (*Aspergillis, Candida, Stachybotrys*) can invade the tissues by growing hyphal elements into them
    - **"boring" devices** - protozoa, including Apicocomplexa such as *Plasmodium*, *Toxoplasma* and helminths, such as Schistosoma, have specialized devices that allow them to "bore" into cells or through tissues; in the Apicocomplexa, it is called an **apical complex**
- **Evasins** - **protect** pathogen from host defense factors, especially phagocytes, which allows bacteria to **evade** the host defense system and makes it more possible for them to grow within the tissues
    - **capsules** - fungi, like *Cryptococcus,* that infect in their yeast form use these to avoid phagocytosis; bacteria like *Haemophilus influenzae*, *Neisseria meningitidis* and *Streptococcus pneumoniae* use these to avoid phagocytosis ... here's how phagocytosis is *supposed* to work (movies courtesy of ASM MicrobeLibrary, Author: James A. Sullivan, CellsAlive)
    - **catalase** - enzyme produced by *Candida* and other fungi as well as *Staphylococcus aureus* and other bacteria to degrade peroxides, thus promoting survival inside phagocytes
    - **coagulase -** enzyme produced by *Staphylococcus aureus* and *Yersinia pestis* that promotes blood clotting (coagulation), thereby walling-off the site of infection and protecting these bacteria from phagocytosis; this also causes the characteristic appearance of the skin in black plague
    - **M protein** - this surface protein is produced by *Streptococcus pyogenes* to inhibit surface complement activation (which would cause opsonization)
    - **leukocidins** - *Staphylococcus aureus, Streptococcus pyogenes* and other bacteria use these to kill phagocytes by damaging their membranes
    - **anti-phagocytic factors** - various factors allow **protozoans** such as *Leishmania* and **bacteria** such as *Chlamydia, Listeria, Mycobacterium, Rickettsia,* and *Salmonella* to survive within phagocytes ... check out this Salmonella animation to see how Salmonella does this; **fungi** use **hyphae** and **pseudohyphae** as antiphagocytic factors
    - **Intracellular growth** - allows many bacteria, fungi and protozoa to "hide" from the host defense system
    - **immune system blockades** - viruses and some bacteria can produce (or trigger the host cell to produce) molecules that shut down the immune response to the parasite
- **Toxins** - this is a general category that includes any molecule that can promote **damage** to the cells or tissues of the host
    - **toxic molecules produced by bacteria and fungi include:**
        - **exotoxins** - toxic proteins that are secreted by living microbes

        - **bacterial examples**
            - **botulin** - *Clostridium botulinum* neurotoxin causes **flaccid paralysis** in botulism
            - **tetanospasmin** - *Clostridium tetani* neurotoxin causes simultaneous contraction of opposing muscles, resulting in **tetany**, which is painful and makes tetanus a life-threatening disease
            - **enterotoxin** - *Escherichia coli*, *Staphylococcus aureus*, *Vibrio cholerae* and other bacteria produce this toxin, which causes intestinal cells to pump water and salts (electrolytes) from the bloodstream into the intestine, causing **diarrhea** that leads to **dehydration**, **shock**, and even death in the worst cases
            - **diphtheria toxin** - *Corynebacterium diphtheriae* produces this exotoxin, which damages cells of the heart, kidneys and central nervous system by **inhibiting protein synthesis**, thus resulting in diphtheria
        - **fungal example - gliotoxin** this exotoxin causes the bright red inflammation seen in *Candida* infections
    - **endotoxin** - lipopolysaccharide (LPS) portion of the outer membrane of Gram-negative bacterial cell walls which is released when the bacteria disintegrate and causes **fever** and/or **endotoxin shock**, depending on its concentration in the bloodstream
- **animal viruses - consequences of virus infection of a animal host cell include:**
    - **Lytic infection** - viral nucleic acid initiates destructive replication cycle in which progeny virions are produced and the host cell is destroyed
        - Picornavirus replication
        - Herpes virus replication
    - **Persistent infection** - host cell remains alive and produces progeny virions at a slow rate, but for a long time
    - **Latent infection** - there is a delay between infection of the host cell and generation of progeny virions
    - **Transformation** - the viral nucleic acid triggers neoplastic changes in the host cell which "immortalilze" it and cause uncontrolled growth, which can lead to tumors (cancer) in the host
        - **benign tumor** - noninvasive ... tumor cells, often enclosed in a "capsule" of host tissue, do not spread to other tissues
        - **malignant (metastatic) tumor** - invasive ... tumor cells spread to other tissues and proliferates there
- **protozoa** can be **directly toxic** to cells - *Entamoeba histolytica* is **cytotoxic** to intestinal cells as a result of its ability to bind to them, then secrete molecules that generate holes in the intestinal cells' cytoplasmic membranes, resulting in the diarrhea seen in amebic dysentery
- **toxicity can also be triggered by viruses and other intracellular parasites** ... as a result of various types of damage to the internal structures, external structures

(modification of erythrocyte membranes in malaria) or functional molecules of host cells
    - **damage or toxicity can be triggered as a result of an inappropriate immune response** by the host, as seen in schistosomiasis

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Epidemiology

Definitions

- **Epidemiology** - study of the occurrence of disease in a human population, especially the cause (**etiology**) and transmission of disease
- **Epidemic** - literally, "upon the people" (*epi* = upon; *demos* = people); commonly refers to an unusually high incidence of a disease in a community (population) at one time
- **Prevalence** - the *proportion* (or percentage) of diseased individuals in a population at one time
- **Incidence** - the *number* of diseased individuals in a population at one time
- **Pandemic** - literally, "all the people" (*pan* = all; *demos* = people); indicates an epidemic involving more than one continent or a worldwide epidemic
- **Endemic** - literally, "in the people" (*en* = in; *demos* = people); a disease is constantly present, usually at low incidence, in a population
- **Outbreak** - appearance of several cases of a disease, usually in a short period of time, in an area previously experiencing no cases or only sporadic (scattered or isolated) cases of the disease; "mini" epidemic
- **Morbidity** - disease; sickness; clinical illness
- **Mortality** - death
- **Reservoir** - a site in which infectious agents remain viable (alive) and from which infection of individuals may occur
- **Carrier** - an infected individual which is not showing obvious signs or symptoms of clinical disease, but which is shedding the etiologic agent for a long period of time (greater than six months)
- **Zoonoses** - diseases which occur primarily in animals but are occasionally transmitted to people (plague, Lyme disease, rocky mountain spotted fever)
- **Vector** - *living* agent which transmits infectious agent (ticks, fleas, flies mosquitoes)
- **Fomite** - *non-living* object that transmits infectious agents (pencil, doorknob, handkerchief); fomites such as food or water are called **vehicles**

Koch's Postulates

If a microorganism is the causative (etiologic) agent of an infectious disease, it must be:

- **Present** in every case of the disease, but absent from the healthy host
- **Isolated** and grown in pure culture
- Able to **Cause** the disease when a pure culture is inoculated into a healthy host
- **Re-isolated** from the host that was inoculated with the pure culture

Transmission of Infectious Diseases

- **Stages in transmission**
  - *escape* from old host
  - *travel* to new host
  - *entry* into new host
- **Modes of transmission**
  - *direct* - transmission via
    - **close**, but not intimate, contact (shaking hands, etc.)
    - **intimate** contact (sexual contact)
  - *indirect* - transmission via
    - **vectors**
    - **vehicles or fomites**

Types of Epidemics

- **Common-source**
  - infection or intoxication of many people from a *single contaminated source*
  - characterized by rapid onset, "sharp" peak and rapid decline in incidence
- **Propagated**
  - introduction of an infected person into a susceptible population leads to transfer of the etiologic agent to others, who transfer it to many others
  - characterized by slow onset, "blunted" peak and slow decline in incidence

Introduction of New Pathogens into Susceptible Populations

- Often leads to rapid onset of epidemics that continue until sensitive individuals in the population are selected against or many individuals in the population develop immunity (**herd immunity**) and survive the disease
- Important to native inhabitants of locations such as Hawaii, Central America, Caribbean Islands and all of North America when the European explorer/colonizers "invaded" and brought with them diseases such as measles, gonorrhea and smallpox

Nosocomial (hospital-acquired) Infections

Hospitals are good places to *acquire* infections due to the presence of many patients with infectious diseases

- **Iatrogenic infection** - infections caused as a result of medical procedures (catheterization, injection, surgery, etc.) which have a good potential to introduce microbes into patient tissues
- **Transmission** of microbes between patients by hospital personnel
- **Crowding** leads to cross-infection of patients by direct and indirect means
- **Immunocompromised** people are more susceptible than normal ones due to:
  - *disease* - lower resistance due to damage caused by diseases such as AIDS
  - *treatment* - weakened resistance caused by drug therapy for cancer, etc.

    - *immaturity* - newborns are highly susceptible because their immune systems have not yet had a chance to mature and become fully functional
    - *stress* - decreases resistance and immune response development
- **Antibiotic-resistant strains** - routine use of antibiotics selects for these in hospitals (these strains are frequently resistant to multiple antibiotics)

Public Health Measures for Control of Epidemics

Involves strategies which break the "chain of transmission"

- **Immunization of people**
    - *boosters* frequently required
    - *100% immunization is not necessary* (herd immunity)
- **Blocking vehicle-mediated transmission**
    - *water purification*
    - *effective cooking*
    - *prevention of food contamination* with infectious agents
- **Quarantine**
    - *limiting freedom of movement* of individuals carrying infectious agents
    - *minimum time required* for a quarantine period is equal to *longest period of communicability* (transmissibility) of the disease
- **Elimination of animal reservoirs**
    - *immunization of animals* that act as reservoirs of diseases such as bovine tuberculosis, brucellosis (highly effective when monitored properly)
    - *eradication of animals* that act as reservoirs of diseases such as tularemia, plague, Lyme disease (sometimes effective, difficult to monitor properly)

Global Health Considerations

- **Industrial vs. "developing" countries** - different disease patterns are found in different countries because of varying lifestyles and levels of poverty (which relates to poor community health infrastructure and medical treatment)
- **Travel to endemic areas** - immunization is helpful when possible and may be required before travel can be initiated